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In The

Supreme Court of the United States

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COMMONWEALTH OF MASSACHUSETTS, ET AL.,
PETITIONERS,

v.

ENVIRONMENTAL PROTECTION AGENCY, ET AL.,
RESPONDENTS.

♦

ON PETITION FOR WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE DISTRICT OF COLUMBIA CIRCUIT

♦

Brief *Amicus Curiae* of ERNEST L. DAMAN, TOM A. HENDRICKSON NATHAN H. HURT, KLAUS S. LACKNER, DENNIS K. McBRIDE, A. ALAN MOGHISSI, HAROLD W. OLSEN, PAOLO F. RICCI PETER P. ROGERS and RICHARD WILSON in Support of Respondent

♦

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QUESTIONS PRESENTED

1. Whether the Administrator of the Environmental Protection Agency has authority to regulate air pollutants associated with climate change under section 202(a)(1) of the Clean Air Act, 42 U.S.C. 7521(a)(1).

2. Whether the EPA Administrator may decline to issue emission standards for motor vehicles based on policy considerations not enumerated in section 202(a)(1) of the Clean Air Act.

PARTIES TO THE PROCEEDINGS BELOW

Petitioners, who were petitioners in the court of appeals, are the Commonwealth of Massachusetts, the States of California, Connecticut, Illinois, Maine, New Jersey, New Mexico, New York, Oregon, Rhode Island, Vermont, and Washington, the District of Columbia, American Samoa Government, New York City, the Mayor and City Council of Baltimore, Center for Biological Diversity, Center for Food Safety, Conservation Law Foundation, Environmental Advocates, Environmental Defense, Friends of the Earth, Greenpeace, International Center for Technology Assessment, National Environmental Trust, Natural Resources Defense Council, Sierra Club, Union of Concerned Scientists, and U.S. Public Interest Research Group.

Respondents are the Environmental Protection Agency, and the Alliance of Automobile Manufacturers, National Automobile Dealers Association, Engine Manufacturers Association, Truck Manufacturers Association, CO_2 Litigation Group, Utility Air Regulatory Group, and the States of Michigan, Alaska, Idaho, Kansas, Nebraska, North Dakota, Ohio, South Dakota, Texas, and Utah (intervenors below).

CORPORATE DISCLOSURE STATEMENT

Amici are individuals, who appear here in their individual capacities, and not as officers, directors or members of any institution with which they are affiliated.

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in Support of Respondent

♦

INTEREST OF *AMICI CURIAE*

Amici respectfully submit this brief as *amici curiae* in support of the Respondents.[1, 2]

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[1] The parties have consented to the filing of this brief; their letters of consent are on file with the Clerk of the Court. In accordance with Rule 37.6, *amici* state that no counsel for either party has authored this brief in whole or in part, and no person or entity other than *amici* has made a monetary contribution to the preparation or submission of this brief.

[2] *Amicus* Dennis K. McBride is President of the Potomac Institute for Policy Studies, a non-partisan, independent "think tank" which does (continued...)

Amici are scientists and engineers with diverse views on the projected global climate change as a consequence of increases in the atmospheric carbon dioxide ("CO_2"). Some *amici* think that societal action to control global atmospheric carbon dioxide concentrations in the atmosphere is long overdue. Other *amici* are concerned about the economic impact of overly hasty action. However, *amici* agree that regulating the CO_2 emissions from automobiles under the Clean Air Act is not the appropriate way to attempt to control these global concentrations and may well have an economic cost that far exceeds using other alternatives. This conclusion should, however, not be taken as opposition to more direct and inclusive methods of addressing increasing carbon dioxide concentrations in the atmosphere.

Amici believe that Petitioners and certain of the *amici* filing briefs in support of petitioners[3] oversimplify and to some extent conflate diverse and not wholly consistent concepts in trying to suggest that regulating motor vehicle tailpipe emissions, particularly of carbon dioxide, will have a significant impact on climate change.

STATEMENT OF THE CASE

This case involves review of the U.S. Environmental Protection Agency's ("EPA" or "Agency") denial in 2003 of a petition for rulemaking, filed in 1999, asking the Agency to

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[2](...continued)
work for the Congress, the Executive branch and the Judiciary. It does no work for respondent EPA. It has done work for the Department of Energy, largely collaborative with the National Laboratories (primarily Sandia and Los Alamos) on high tech national security and homeland security issues. None of its work for DOE has been concerned with hydrocarbon energy.

Amicus A. Alan Moghissi is President of Institute for Regulatory Science, which also does work for the Department of Energy, primarily designing and conducting peer reviews of DOE science projects.

[3] *E.g.* Brief of *Amici Curiae* Climate Scientists David Battisti, *et al.*

regulate greenhouse gas emissions from new motor vehicles under section 202(a)(1) of the Clean Air Act (the "Act" or "CAA"), 42 U.S.C. § 7521(a)(1) (2000), to address global climate change.[4] Petitioners based their request on the argument that EPA had a "mandatory duty" under the Act to regulate those emissions. Control of Emissions from New Highway Vehicles and Engines, Notice of denial of petition for rulemaking, 68 Fed. Reg. 52922, 52923 (Sept. 8, 2003), A-59, A-60. After giving the public an opportunity to comment on the rulemaking petition and considering public comments, EPA denied the petition. *Id.* at 52922-33, A-59 to A-93.

EPA set forth three grounds for its denial of the petition. First, it determined, based on the Act's language and legislative history, other statutes, congressional decisions, and principles of statutory

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[4] Sections 108 and 109 of Title I of the Clean Air Act, 42 U.S.C. 7408-7409, authorize the Environmental Protection Administration ("EPA") to set national ambient air quality standards ("NAAQS") for air pollutants that cause or contribute to air pollution that may reasonably be anticipated to endanger public health or welfare and that are emitted by numerous or diverse sources. Title II of the Act establishes a regulatory framework for federal control of pollution from motor vehicles and other mobile sources. *See* Clean Air Act, Sections 202-250, 42 U.S.C. 7521-7590. This case involves Section 202(a)(1) of the Act, 42 U.S.C. 7521(a)(1), which authorizes EPA to "prescribe * * * standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles or new motor vehicle engines, which in [EPA's] judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare." Section 302 of the Act, 42 U.S.C. 7602, sets forth general definitions applicable to the Act as a whole. Section 302(g), 42 U.S.C. 7602(g), defines "air pollutant" as "any air pollution agent or combination of such agents, including any physical, chemical, biological, [or] radioactive * * * substance or matter which is emitted into or otherwise enters the ambient air" including any precursors to the formation of such air pollutant. "[E]ffects on welfare" is defined to include "effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility, and climate, and damage to * * * property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being." 42 U.S.C. 7602(h).

interpretation in *FDA v. Brown & Williamson Tobacco Corp.*, 529 U.S. 120 (2000), that it lacked authority under the Clean Air Act to regulate greenhouse gas emissions for the purpose of addressing global climate change. *Id.* at 52925-29, A-68 to A-79. EPA also stated that "[i]n light of Congress' attention to the issue of global climate change, and the absence of any direct or even indirect indication that Congress intended to authorize regulation under the Act to address global climate change, it is unreasonable to conclude that the CAA provides the Agency with such authority." 68 Fed. Reg. at 52928, A-78.

Second, EPA found that the only practical way to reduce tailpipe emissions of CO_2, the most prevalent greenhouse gas, is to improve fuel economy. 68 Fed. Reg. at 52929, A-79 and that any EPA effort to set CO_2 tailpipe standards under the Act would either abrogate EPCA's regime if the standards were more stringent than the applicable fuel economy standard or be meaningless if they were less stringent. *Id.*, A-80, and that even if the Act authorized it to regulate greenhouse gas emissions to address global climate change, granting the rulemaking petition would conflict with Title V of the Energy Policy and Conservation Act ("EPCA"), 49 U.S.C. §§ 32901-32919, which authorizes the Department of Transportation to establish fuel economy standards for motor vehicles. *Id.* at A-79 to A-80.

Third, EPA determined that, even if the Act did provide EPA with authority to regulate greenhouse gas emissions to address global climate change, section 202(a) of the Act -- the provision at issue in the rulemaking petition -- gives EPA's Administrator discretion to determine "in his judgment" whether, based on the facts before the Agency, the emissions in question "may reasonably be anticipated to endanger public health or welfare." 42 U.S.C. § 7521(a)(1), and that the Administrator had never made a determination under the Act that greenhouse gas emissions endanger public health or welfare and that the timing of any such endangerment determination is within the Administrator's discretion. 68 Fed. Reg. at 58929, A-80 to A-81.

EPA thus determined that, contrary to petitioners' argument, it had no mandatory duty to undertake rulemaking.

EPA also found that the scientific evidence before it, including the National Research Council's report, *Climate Change Science: An Analysis of Some Key Questions* (2001), was "extraordinarily complex and still evolving" and reflected "'considerable uncertainty in current understanding of how the climate system varies naturally and reacts to emissions of greenhouse gases.'" 68 Fed. Reg. at 52930, A-83 (quoting NRC Report). EPA noted that, given the global nature of atmospheric concentrations of CO_2, it is "extremely difficult to evaluate" to what extent any "effects in the U.S. would be related to anthropogenic [CO_2] emissions in the U.S." *Id.* at 52927, A-73. In light of the scientific uncertainty on these critical issues, EPA found no basis for making an endangerment determination and regulating motor vehicles' greenhouse gas emissions under section 202(a) of the Act. *Id.* at 52931, A-86 (declining to regulate "[u]ntil more is understood about the causes, extent and significance of climate change"). EPA concluded that "establishing [greenhouse gas] emission standards for U.S. motor vehicles at this time would require EPA to make scientific and technical judgments without the benefit of the studies being developed to reduce uncertainties and advance technologies." *Id.*, A-85.

EPA also denied the rulemaking petition because it determined that, even if it had authority under the Act to undertake rulemaking, it had neither an obligation nor a sound basis to do so.

Petitioners sought review of EPA's denial by the U.S. Court of Appeals for the District of Columbia Circuit. Without reaching the issue whether the Act provides EPA with authority to regulate for global climate change purposes, a panel of the D.C. Circuit held, in an opinion by Judge Randolph, that assuming *arguendo* that EPA has such authority, EPA properly exercised its discretion in denying the rulemaking petition. *Massachusetts v. EPA*, 415 F.3d 50, 56 & n.1, 58 (D.C. Cir. 2005), A-10 & n.1 and A-15; *see also id.* 415 F.3d at 61, A-20 (Sentelle, J., concurring in the

judgment). Judge Tatel dissented, believing that EPA had "misinterpreted the scope of its statutory authority" and had provided a legally inadequate explanation for the petition denial. *Id.* at 82, A-58 (Tatel, J., dissenting). In his view, Section 202(a)(1) authorizes the EPA Administrator, in determining whether a pollutant "in his judgment cause[s], or contribute[s] to, air pollution which may reasonably be anticipated to endanger public health or welfare," only "to determin[e] whether the statutory standard for endangerment has been met." *Id.* at 74. Moreover, Judge Tatel concluded that the scientific uncertainties associated with global warming, see id. at 74, the overlapping responsibilities of the Department of Transportation in setting fuel economy standards, *see id.* at 68, and the potential for interference with the United States' ongoing negotiations with other nations, *see id.* at 80-81, did not justify EPA's action.

The court of appeals denied a petition for rehearing *en banc*.

SUMMARY OF ARGUMENT

Although the relationship between emissions of CO_2 and its atmospheric concentration is complex, it is generally agreed that the combustion of fossil fuels constitutes the primary reason for the recent increases in the atmospheric CO_2 concentration. Although CO_2 is a very important greenhouse gas, there are numerous other greenhouse gases: water vapor, which is responsible for approximately 35 to 70 percent of the greenhouse effect far exceeds the contribution of CO_2, which accounts for 10 to 25 percent.

The current case concerns only the emissions of CO_2 (and certain other gases) from cars and light trucks, but it is estimated that approximately one-fourth (25%) of total world emissions comes from cars and light trucks. Consequently, regulating CO_2 emissions from cars would leave about three-quarters of world emissions unregulated. Regulating CO_2 emissions based on its impact on global climate change, should include regulating emissions from the primary source of CO_2 emissions which at the

present time are from various industrial sources, including electricity generation using coal, oil and natural gas.

Regardless of the actions of the United States and other industrial countries, it is estimated that by about 2035 CO_2 emissions from countries not covered by the Kyoto Protocol will exceed CO_2 emissions from countries covered by Kyoto Protocol. The need is for a more comprehensive approach than mere regulation of CO_2 emissions by new motor vehicles in the United States. The limited regulation proposed by petitioners would only have a limited impact on the hypothesized and projected global climate change resulting from the increases in the atmospheric concentration of CO_2.

The justification and procedure for regulation of the more usual air pollutants under the Clean Air Act are logically and practically hard to square with control of CO_2 concentrations. EPA's determination was correct because one cannot consider CO_2 as an air pollution agent that needs to be controlled in the way conventional pollutants are controlled.

Even though climate change may well be a problem, it is the full carbon cycle that needs to be regulated, not merely the emission of CO_2.[5] Regulating tailpipe emissions from cars and light trucks under the Clean Air Act to accomplish the goal of reducing "greenhouse gases" and global warming is the wrong procedure, will be ineffective, and fails to give the right incentives either to the other branches of government or to other countries.

Regulating the CO_2 emissions from automobiles and light trucks under the Clean Air Act is not the appropriate way to attempt to control global concentrations of "greenhouse gases"

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[5] The easiest way to see this is to consider biofuels: cars running on alcohol or biodiesel emit CO_2 but this CO_2 does not contribute in a net way to climate change. In other words, the CO_2 emission is harmless as long as it is balanced by CO_2 capture. Biofuels release carbon that has been captured by photosynthetic processes a short time prior to its emission.

and may well have an economic cost that far exceeds using other alternatives.[6]

ARGUMENT

Amici believe that regulating the CO_2 emissions from automobiles under the Clean Air Act is not the appropriate way to attempt to control these global concentrations and may well have an economic cost that far exceeds using other alternatives.

1. Carbon dioxide is an essential compound for maintenance of life on earth. Without CO_2 there would be no ecosystem, no plants, meaning no nourishment for most animals that are part of the human food chain, and thus no food for humans. Therefore, it is not simply the elimination of CO_2 from the atmosphere, but maintaining a concentration level that supports animal and plant life without having an adverse impact on climate and other life systems. Although, at the present time and in the foreseeable future, there is no scientifically acceptable method to establish a precise environmental standard for CO_2 concentrations, there is general agreement that it would be wise to limit them or at least slow their increase.

2. There has been considerable variation in the quantity of atmospheric CO_2 due to the equilibrial nature of interacting global and solar variables. The variation over the past 400,000 years has ranged from under 200 ppmv to over 300 ppmv. Concentration of CO_2 in the atmosphere has increased rapidly during the past century from about 300 parts per million by volume (ppmv) to

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[6] For example, a power plant that uses wood or other biomass as a fuel and that captures carbon dioxide and stores it permanently, could be used to compensate for the fossil carbon consumption on board a vehicle. Trading two different carbon transactions against each other shows that simply treating CO_2 emission from a vehicle's tailpipe as an emission of a dangerous pollutant that needs to be eliminated or severely reduced is too simplistic and could be counterproductive. It could effectively stymie any development of methods capturing carbon dioxide from the air through biomass or other means, not because it would not be effective, but because regulations would not create an incentive for this approach.

about 380 ppmv.[7] This increase appears similar to the four previous upswings over the past half-billion years, each of which was followed by downswings. The major CO_2 variations occur in approximately 100,000 year cycles, and there were approximately ten smaller cycles within the five major 100,000 year trends. Combustion of fossil fuels; certain industrial activities; deforestation and combustion of woods and other organic matter removed from forests (which "consume" CO_2 and release O_2) add to the net quantity of CO_2 in the atmosphere.[8]

There are also natural sinks for CO_2 These are primarily associated with annual growth of plants and year-round uptake by oceans. The measurements begun by Keeling, *et al.*[9] at Mauna Loa, and continuing to the present day, clearly show diurnal variation in CO_2 concentrations. Uptake of CO_2 to the shallow oceans is relatively fast on a year-to-year timescale[10], whereas the mixing of the shallow oceans with the very large sink deep oceans is relatively slow. In fact such sink mixing is slower than the present rate of increase in atmospheric concentrations and therefore the absorption of CO_2 into the deep ocean sink is slower than the present rate of rise of the concentrations.[11]

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[7] National Academy of Science, Committee on Science, Engineering, and Public, "Public Policy Implications of Greenhouse Warming," figure 3.1 at 12 (1991), available at http://www7.nationalacademies.org/cosepup/.

[8] *See, e.g.*, M.R. Allen., *et al.*, "Quantifying the uncertainty in forecasts of anthropogenic climate change," *Nature* 407 (2000).

[9] C.D. Keeling, R.B, Bacastiw, A.E. Bainbridge, A. Ekhdahl, R. Guenther and S. Waterman, "Atmospheric carbon dioxide variations at Mauna Loa Observatory Hawaii," 28 *Tellus* 538-551 (1973).

[10] C.D. Keeling, "The Carbon Dioxide Cycle," in CHEMISTRY OF THE LOWER ATMOSPHERE (S.I. Raoul, ed.) (1973).

[11] U. S. Environmental Protection Agency, Office of Policy, Inventory of U. S. Greenhouse Emissions and Sinks, 1990-2004 (EPA 430-

(continued...)

3. Although the relationship between emissions of CO_2 and its atmospheric concentration is complex, it is generally agreed that the combustion of fossil fuels constitutes the primary reason for the recent increases in the atmospheric CO_2 concentration.[12] But it must be recognized that limiting CO_2 emissions is not the same as limiting CO_2 concentrations.

4. The idea that the earth is a "greenhouse" dates back at least to the suggestion of Jacques Fourier.[13] Laboratory measurements show that CO_2 absorbs infrared radiation and therefore can help create a greenhouse. This hypothesis dates to the work of Tyndall in 1870s. CO_2 can therefore in modern parlance loosely be called a "greenhouse gas (GHG)." The work of Arrhenius showed that past world temperature changes might be related to CO_2 concentration.[14] Recent work shows that although CO_2 is a very important greenhouse gas, there are numerous other greenhouse gases. In particular, water vapor (which is responsible for approximately 35 to 70 percent of the greenhouse effect (this varies with geographical location) exceeds CO_2 (which is probably 10 to 25 percent responsible) in importance. Other gases responsible for contributing to the greenhouse effect include methane (5 to 9 percent), chlorofluorocarbons (CFCs), nitrous oxide (N_2O) and numerous other gases. If there were no change in the concentration of water vapor and other greenhouse gases, the global-mean surface temperature would increase by $T_d = 1.2C$, for a static doubling of CO_2. This estimate is based upon

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[11](...continued)
R-06-002) (hereafter "EPA Inventory") at 7 (2006) .

[12] See J.E. Hansen, *et al.*, "Climate forcings in the industrial era," 95 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES 753-758 (1998).

[13] J.A. Fourier, 7 *Mem. Acad. Sci. Inst. Fr.* 569 (1839).

[14] S. Arrhenius, "On the influence of carbonic acid in the air upon the temperature of the ground," 41 *Philosophical Magazine* 237 (1896).

laboratory data on absorption of infrared radiation by CO_2 and is usually considered reliable.[15]

Concentrations of atmospheric water vapor are generally expected to increase with increasing temperature, and since water vapor is the most important greenhouse gas, this could amplify warming. It is the estimate of the reliability of this expectation that creates the biggest uncertainty in the scientific understanding, and therefore of much of the controversy on the need for regulation.

Each GHG has an associated Global Warming Potential (GWP) number. Using CO_2 as the base (value of 1.00), methane has a GWP of 21 and SF_6 has a GWP of 23,900,[16] which indicates the wide range of GWP values. The warming impact of a GHG is the product of its GHG concentration in the atmosphere and its GWP.

Another important issue is the technically defined residence time of an atmospheric gas. This is basically the measurement of the estimate of the tenure of a gas in its beginning molecular form. Like GWP, residence times vary among compounds. The residence time of a GHG is important for the assessment of its impact. For example, whereas the residence time of water vapor in the atmosphere is short and highly variable, the residence time of CO_2 is estimated to range from 50 to 800 years, depending upon the assumptions about certain variables -- primarily associated with the time for ocean mixing -- used in the calculations, as noted above.

5. The statements in point (4) above have been confirmed by laboratory experiments. Specifically, these indicate that higher concentrations of CO_2 in a greenhouse are associated with higher temperature if all other conditions (most importantly the energy

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[15] National Academy of Sciences, Committee on Science, Engineering, and Public Policy, "Policy Implications of Greenhouse Warming" (1991), available at http://www7.nationalacademies.org/cosepup/

[16] EPA Inventory, Table 1-2, at 7 (2006).

input) remain constant.[17] In a vast over-simplification, the past global temperature rise was often referred to as the "greenhouse effect." Other observations indicate that the earth's greenhouse is affected by other complex interactions of the Earth and the solar system.[18]

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[17] "It can be said with a high level of confidence that global mean surface temperature was higher during the last few decades of the 20th century than during any comparable period during the preceding four centuries. This statement is justified by the consistency of the evidence from a wide variety of geographically diverse proxies. Less confidence can be placed in large-scale surface temperature reconstructions for the period from A.D. 900 to 1600. Presently available proxy evidence indicates that temperatures at many, but not all, individual locations were higher during the past 25 years than during any period of comparable length since A.D. 900. The uncertainties associated with reconstructing hemispheric mean or global mean temperatures from these data increase substantially backward in time through this period and are not yet fully quantified." National Academy of Sciences, Board on Atmospheric Sciences and Climate, SURFACE TEMPERATURE RECONSTRUCTIONS FOR THE LAST 2,000 YEARS (2006).

[18] These include variability in the output of the Sun itself. This issue is far from settled (*see* Foukal, *et al.*, "Variations in Solar Luminosity and Their Effect on the Earth's Climate," 443 *Nature* 161-166 (2006)) and is not concerned exclusively with the quantity of energy radiated from the sun, but is also concerned with the spectral changes in solar output. For a comprehensive treatment of solar variability. (*see* D.V. Hoyt and K.H. Schatten, THE ROLE OF THE SUN IN CLIMATE CHANGE (1997)). A recent paper provides experimental data to support this hypothesis. H. Svensmark, J.O.P. Pedersen, N.D. Marsh, M.B. Enghoff, U.I. Uggerhøj, "Experimental Evidence for the Role of Ions in Particle Nucleation Under Atmospheric Conditions," 462 Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences 1773 (Oct. 3, 2006), available at http://www.journals.royalsoc.ac.uk/(5helzf45nxp3va55eoguqt55)/app/home/contribution.asp?referrer=parent&backto=issue,12,46;journal,1,133;linkingpublicationresults,1:102023,1. This paper suggests that the ions are active in generating an atmospheric reservoir of small thermodynamically stable clusters, which are important for nucleation processes in the atmosphere and ultimately for cloud formation.

6. CO_2 emissions from mobile sources (i.e. transportation) constitute about one-third of the total world CO_2 emissions.[19] The current regulatory issue, of course, concerns only the emissions of CO_2 from cars and light trucks. Since all transportation consists of much more than cars and light trucks and includes heavy trucks, trains, air transportation and other sources, it is estimated that approximately one-fourth (25%) of total world emission comes from cars and light trucks. Consequently, regulating CO_2 emissions from cars would leave about three-quarters of world emissions unregulated.

7. If we consider the *maximum* reasonable estimate of the contribution of CO_2 to the greenhouse effect (50 percent), then 25 percent (from car and truck transportation) of 50 percent, or only 12.5 percent theoretically maximal reduction would be achieved by limiting tailpipe CO_2 emissions from passenger cars and light trucks. We could achieve this theoretical 12.5 percent reduction only if we reduced car and truck emissions of CO_2 to <u>*zero*</u>, which is impracticable.[20] Moreover, other estimates of the contribution of CO_2 to the greenhouse effect range from 9 to 26 percent,[21] which would mean that the total reduction in greenhouse gas from completely eliminating emissions from cars and light trucks would be from just over 2 percent (.09 x .25) to 6.5 percent (.26 x .25). Furthermore, as noted above, regulating CO_2 emissions from cars not only would leave 75% of the CO_2 emissions unregulated, it would have no effect on the varying quantity of naturally occurring CO_2.

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[19] EPA Inventory, Table ES-3 at ES-7 (2006). Transportation constitutes 1,860.2 out of the total of 5,656.6 $TgCO_2Eq$, or 32.88%.

[20] National Academy of Science, Commission on Engineering and Technical Systems, "Automotive Fuel Economy: How Far Can We Go?" (1992) (available at <u>http://www7.nationalacademies.org/deps/>CETS).</u>

[21] *See, e.g.* J.T. Kiehl, J. T., K.E. Trenberth, "Earth's Annual Global Mean Energy Budget," 78 (2) Bulletin of the American Meteorological Society 197-208 (1997).

Regulating CO_2 emissions based on its impact on global climate change should include regulating emissions from the primary sources of CO_2 emissions, which at the present time are various industrial sources, including electricity generation using coal, oil and natural gas. Moreover merely asking the manufacturers to modify their cars is only a partial, and indirect, solution to this problem. Those who buy cars should also be encouraged not to use them. It is well known that ordinary people are strongly influenced in their actions by price.[22] In principle the analysis of effects and costs should be based on consideration of the entire system or process, not just on the tailpipe emissions of a car or light truck.[23]

A more inclusive solution would, for example, be an increase in gasoline taxes, accompanied by a decrease in other taxes to make the system revenue neutral. This would give appropriate incentives to all sectors of the economy. A more inclusive carbon tax, which would apply to all fuels and processes that emit CO_2, would be preferable. Microeconomists have argued that such a procedure would be stimulating to the economy.[24]

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[22] *See* P.F. Ricci, ENVIRONMENTAL RISK ASSESSMENT AND MANAGEMENT: PRINCIPLES AND PRACTICES (2006); *see also* P. F. Ricci, "Mortality, Air Pollution, and Energy Production: Uncertainty and Causality," 116 *J. Energy Engineering* 148 (1990).

[23] *See* L.A. Cox and P.F. Ricci, "Health-Risk Assessment: Production of Electricity," 116 *J. Energy Engineering* 130 (1990); A. Kalelkar, J. Fiksel, P.F. Ricci, and T.L. Cox, "Occupational Risks of Energy Production," 24 Nuclear Safety 459 (1983); P.F. Ricci, "Mortality, Air Pollution, and Energy Production: Uncertainty and Causality," *supra*, n. 21.

[24] D.W. Jorgensen, and P.J. Wilcoxen, "Reducing U.S. Carbon Dioxide Emissions: the Cost of Different Goals," John F. Kennedy School of Government, Center for Science and International Affairs, Discussion Paper 91-9 (1991). Professor Jorgensen testified before the Senate Committee on Environment and Public Works (July 10, 1997): "Our overall conclusions are, first, that a carbon tax is superior to other tax instruments. Second, by using the revenues to reduce the most burdensome taxes, namely taxes on income from capital, economic growth can be stimulated rather

(continued...)

Those who advocate regulating motor vehicle CO_2 emissions in the United States based on its impact on global climate change logically should seek to reduce significantly emissions from all sources of CO_2 emissions of into the atmosphere, which, as indicated, includes industrial sources, and electricity generation using coal, oil and natural gas. Credit should also be given to those who provide a sink for CO_2.

8. Regardless of the actions of the United States and other industrial countries, it is estimated that by about 2035 CO_2 emissions from countries not covered by the Kyoto Protocol will exceed CO_2 emissions from countries covered by the Kyoto Protocol.[25] This emphasizes the need for a more comprehensive approach than mere regulation of motor vehicles CO_2 emissions in the United States. The regulation proposed by petitioners would only have a limited impact on the hypothesized and projected global climate change resulting from the increases in the atmospheric concentrations of CO_2.[26] This could only be

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[24](...continued)
than retarded. . . . To sum up: The economics of climate change is well understood. The optimal policy...involves a modest reduction in the growth of greenhouse gas emissions. This should provide the basis for any international agreement that would supersede the United Nations Framework Convention of 1994. However, this involves smaller reductions than our existing climate policy, the U.S. Climate Change Action Plan." Professor Jorgensen's testimony can be found at http://epw.senate.gov/105th/jorg0710.htm.

[25] In fact, "... two-thirds of the carbon dioxide emissions in this century are expected to come from developing countries. . ." based on the Intergovernmental Panel on Climate Change ["IPCC"] "Business-As-Usual" or "mid-range" model (Is92a), IPCC, Third Assessment Report, Intergovernmental Panel on Climate Change, Technical Summary of the Working Group I Report of the Intergovernmental Panel on Climate Change (2001). *See* U. S. Department of Energy, Framework for an Energy Security and Climate Stabilization Strategy at 10 and Fig. S10 (2004).

[26] There is no mention, either in Petitioners' Brief or in the brief of the Climate Scientists, David Battisti, *et al.*, of ways of dealing with the (continued...)

rationalized as an example for all other countries emitting CO_2, but it is not a practical way of dealing with greenhouse gases or global climate change. A more direct and inclusive method of control of concentrations is needed than that authorized by the Clean Air Act, and would involve many national jurisdictions.

9. It is important to understand the technical rationale for regulating atmospheric gases and other compounds. Specifically, the emission limits for an air pollutant established by the EPA are overwhelmingly based on one of the following considerations:

a. The compound is a hazardous air pollutant and is regulated on the fundamental claim that it causes adverse human health or other adverse effects at some organic level. Concerns about pollution often have led to appeals for zero concentration of the pollutant. This obviously cannot be achieved, but there is a National Emission standard for Hazardous Air Pollutant (NESHAP) for each of these pollutants. CO_2 is not a hazardous air pollutant in this sense.[27] It occurs naturally, is produced by animal and

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[26](...continued)
global problem, except to acknowledge that when Congress has addressed the issue, it has done so in terms of calling for further research and other nonregulatory measures, *see, e.g.*, Pet. Br. at 23, nor is there any analysis or even estimate of the impact on worldwide greenhouse gas emissions or global warming of the rulemaking they advocate.

[27] Of course, as the renowned sixteenth century German-Swiss alchemist and physician Paracelsus (Theophrastus Philippus Aureolus Bombastus von Hohenheim) (sometimes called the father of toxicology) explained, "All substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy." *See* Doull & Bruce, "Origin and Scope of Toxicology," in CASARETT & DOULL'S TOXICOLOGY: THE BASIC SCIENCE OF POISONS (3d ed. 1986). Succinctly put, "[t]he dose makes the poison." *National Bank of Commerce v. Assoc. Milk Producers, Inc.*, 22 F. Supp.2d 942, 958 (E.D. Ark. 1998); *see also* FOUR TREATISES OF THEOPHRASTUS VON HOHENHEIM (H. E. Sigerist, ed.) (1941); *see also* W. Pagel, *Paracelsus* (2d ed. 1982). In other words, the amount of a substance to which a person is exposed is as important as the nature of the substance.
(continued...)

human respiration and metabolism, and is essential for plant life. It would obviously be impossible and wrong-headed to even aim for zero emissions of CO_2, although a national *net zero* emissions level might be possible when emission and sequestration of CO_2 are averaged. It would be unrealistic to develop a NESHAP for CO_2. Moreover, since CO_2 is CO_2 regardless of its source, any theoretical decision to develop a NESHAP for CO_2 would have to include at least the larger sources of CO_2 emissions, notably industrial coal and other fossil fuel power plants, and thus a large segment of industry. In fact, to establish a NESHAP for only one source of CO_2 would create an unusual, and probably undesirable, precedent for regulation.

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[27](...continued)
For example, small doses of aspirin can be beneficial, but at very high doses this common medicine can be injurious or even fatal.

Thus while it is true that "The dose makes the poison," that proposition has no relevance to a discussion of the nature of CO_2 because there is no likelihood that atmospheric CO_2 concentrations will reach a level that will create a health risk, let alone reach a level that would be itself toxic. A study of nine nuclear ballistic submarines reported average CO_2 at 3,500 ppm with a high recording of 10,600 and for ten nuclear attack submarines, an average of 4,100 ppm with a peak of 11,300 ppm, yet during the usual months-long deployments of nuclear submarines, this continuous exposure had no adverse effects. *See* R. Hagar, "Submarine Atmospheric Control and Monitoring Brief for the COT Committee, Presentation at the First Meeting on Emergency and Continuous Exposure Guidance Levels for Selected Submarine Contaminants" (2003) While it is true that submarine crews are composed of young, healthy men, the research is clear that CO_2 is not problematic until its concentration reaches about 28,000 ppm, and there one begins to see slight headaches, and "...the bulk of the data indicate a no-observed-adverse-effect level (NOAEL) for CO2 of about 25,000 ppm..." National Academies, Board on Environmental Studies and Toxicology, EMERGENCY AND CONTINUOUS EXPOSURE GUIDANCE LEVELS FOR SELECTED SUBMARINE CONTAMINANTS 40 (2004). Average atmospheric CO_2, even at 800 ppm, is of course much more than an order of magnitude less. (For the emission scenario IS92a, *see supra*, n. 22, the IPCC estimates that the atmosphere will contain slightly more than 700 ppm(v) carbon dioxide in the year 2100.)

b. All regulated pollutants have a National Ambient Air Quality Standard (NAAQS). Because NAAQS pollutants have multiple sources, EPA has developed emission standards to ensure that NAAQS for specific pollutants are not exceeded. If a decision were made to regulate CO_2, the first step would be to develop a NAAQS. That would be a difficult task which would involve extensive preliminary work. The difficulty is that CO_2 is emitted from numerous sources not only in the United States but also elsewhere. For its NAAQS to be effective, EPA would have to regulate global industry and motor vehicle use, which is beyond EPA's jurisdiction or influence. Regulation of a only one source, and a small part, of global CO_2 emissions in an indirect way, is not effective or appropriate.

c. The toxic pollutants presently regulated under the Clean Air Act create a *local*, or in a few cases *regional*, hazard. In contrast emissions of CO_2 add to the *global* average CO_2 concentrations. Moreover while the accumulation of CO_2 in the air poses a risk of climate change, the emissions of CO_2 from a particular car, may or may not contribute to this danger. They do contribute in a net sense if the car is burning petroleum that has been taken from the ground and no other action is taken. They do *not* contribute to this danger if a chemically identical fuel has been made from biomass which collected CO_2 from the air and through photosynthesis converted it into an energy rich form. They do *not* contribute, if the owner of the car or the purveyor of the fuel provides for carbon capture elsewhere in the world economy, as long as this capture reduces net carbon emissions to the atmosphere by an amount that is at least equal to the amount of CO_2 that has been emitted. It is thus not appropriate to refer to CO_2 emitted from vehicle tailpipes as a "dangerous pollutant."

The justification and procedure for regulation of the more usual air pollutants under the Clean Air Act are logically and practically hard to square with control of CO_2 concentrations.[28]

10. A power plant that uses wood or other biomass as a fuel and that captures carbon dioxide and stores it permanently could be used to compensate for the fossil carbon consumption by a particular vehicle. Again, this method of trading two different carbon transactions, perhaps in different parts of the world, against each other shows that simply treating CO_2 emissions from a tailpipe as an emission of a dangerous pollutant that needs to be eliminated is too simplistic and could be counterproductive. For example, it could effectively stymie development of technologies for capturing carbon dioxide from the air (through biomass or other means), not because they would not be effective, but because regulations would create a disincentive for this approach being used.

11. The automobile standards mandated by Congress in 1979 have played a part in reducing CO_2 emissions. It seems to *amici* to be inappropriate to use the courts to modify this legislation in an indirect way through the courts when Congress is obviously capable of doing so if and when American people so desire. There is an urgent need to develop a coherent and scientifically valid process that controls or limits CO_2 concentrations while addressing the energy needs of the world population Such a process should also provide for a technology system that can be applied globally Eventually the control of CO_2 concentrations must be based on an international agreement that includes all

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[28] The attempt in Petitioners' Brief to use the example of chloroflurocarbons (CFCs) which were believed to be responsible for a reduction in ozone concentrations in the upper atmosphere with many undesirable effects is misplaced. CFCs were gradually phased out in the United States and elsewhere in the world. That phase-out was made possible when the world's major producers of CFCs had an alternative available at modest cost and agreed with the phase-out. However in the view of *amici*, affordable control of CO_2 concentrations would necessitate a more direct approach which might ultimately have to include the sequestration of CO_2.

nations and provides for the legitimate desires of developing countries to develop their respective industries and acquire a reasonable living standard. *Amici* submit that developing such a procedure is the role of Congress and the Executive, not of the courts. So far, neither the executive branch of government nor Congress has decided to take this step or give guidance to American people or American business. Petitioners' Brief may be useful in focusing attention on the problem, but it does so without increasing understanding of the intricacies of the issue and is likely to be counterproductive and inhibit an adequate approach to the problem.

12. While a case might be made for addressing such aspects of the full solution as can be addressed at the present moment, it is probable that addressing solutions that only address a part of the problem may end up by being far more expensive for society than addressing the problem -- CO_2 concentrations -- in a more direct, simpler, and inclusive way.[29]

Regulation of CO_2 emissions from passenger cars and light trucks has several drawbacks. First, as pointed out above, it may rule out or at least deter entire classes of solutions because they cannot be couched in the terms of an old regulation which was meant for pollutants whose emission should be prevented, not a compound whose accumulation in the atmosphere should be managed. Secondly, and equally important, the central challenge in making carbon management work is to obtain public acceptance of the new regulatory regime that is to be adopted. From this perspective, it would be extremely counterproductive to have a regulatory agency impose an incomplete solution that intrudes on daily life and may be unjustifiably costly.

Proposals for world regulation that provide incentives for development of the needed scientific and technological development have been made. A comprehensive proposal, including carbon sequestration, has recently been submitted to

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[29] Jorgensen and Wilcoxen, *supra* note 11.

the Norwegian Government by an official commission headed by Joergen Randers of the Norwegian School of Management.[30] In essence, since carbon is extracted from the earth at a limited number of places, and since most of it becomes CO_2 within a relatively short time, this might suggest an even more inclusive and possible method of control.[31]

While *amici* have considerable sympathy for the goal of stabilizing or reducing carbon emissions, they believe that regulating tailpipe emissions from motor vehicles under the Clean Air Act to accomplish these goals is the wrong procedure, will be ineffective, and fails to give the right incentives either to the other branches of government, to the industry, or to American people as a whole.

Amici believe that the court of appeals correctly upheld EPA's decision not to regulate motor vehicle tailpipe emissions of CO_2 and other gases because section 202(a)(1) of the Act, 42 U.S.C. 7521(a)(1) expressly conditions the establishment of motor vehicle emissions standards on a discretionary exercise of the Agency's "judgment" as to whether air pollution related to motor vehicle emissions "may reasonably be anticipated" to endanger public health or welfare. Because that provision expressly invokes the Administrator's "judgment," it provides EPA with discretion

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[30] Report of the Norwegian Commission on Low Emissions, "NOU 2006:18: A climate-friendly Norway," October 4, 2006, English language summary available at http://www.lavutslipp.no/article_1334.shtml. This report suggests a comprehensive approach, only a small part of which involves automobiles and light trucks.

[31] *See* K.S. Lackner, R.Wilson and H-J Ziock, "Free-Market Approaches to Controlling Carbon Dioxide Emissions to the Atmosphere: a Discussion of the Scientific Basis," Global Foundation Conference on "Global Warming and Energy Policy" at 31-46 (American Institute of Physics, Kursunuglu, Mintz and Perlmutter, eds., 2000) (report of a conference held in 1999).

in deciding whether and when an endangerment finding can or should be made in the first instance.

That circuit court's case law consistently reflects the established administrative law principle that a federal agency's decision -- based on the facts and given the circumstances before it -- to decline a request to institute rulemaking proceedings is given a high degree of deference. Such a decision should be overturned "only in the rarest and most compelling of circumstances." *WWHT, Inc. v. FCC,* 656 F.2d 807, 818 (D.C. Cir. 1981); *American Horse Protection Ass 'n v. Lyng,* 812 F.2d 1, 4-6 (D.C. Cir. 1987) (denials of rulemaking petitions entitled to "high end" of range of deference). Indeed, "an agency's refusal to initiate a rulemaking is evaluated with deference so broad as to make the process akin to non-reviewability." *Cellnet Communications, Inc. v. FCC,* 965 F.2d 1106, 1111 (D.C. Cir. 1992). As the D.C. Circuit has held, "there are very few cases in which courts have forced agencies to institute rulemaking proceedings on a particular issue after it has declined to do so." *WWHT,* 656 F.2d at 817, 818 (quoting *Action for Children's Television,* 564 F.2d 458, 472 n.24 (D.C. Cir. 1977).

EPA's denial of the rulemaking petition in this case was reasoned. The record before EPA and the circuit court enabled that court to "assure itself that the agency considered the relevant factors, that it explained the 'facts and policy concerns' relied on, and that the facts have some basis in the record." *American Horse Protection Ass 'n v. Lyng,* 812 F.2d 1, 5. EPA provided a full explanation of its reasons for denying the petition in the Federal Register. 68 Fed. Reg. at 52922-33, A-59 to A-93. The Administrative Procedure Act requires that an agency, in denying a petition for rulemaking, give "a brief statement of the grounds for denial"; 5 U.S.C. § 555(e) (2000) (emphasis supplied).

The mere fact that petitioners disagree with the Agency's conclusion does not mean it was not "reasoned," that EPA failed to explain the facts and policy concerns it relied on, or that the facts relied on lack some basis in the record.

The Agency identified a number of reasons -- including, but not limited to, what it perceived as the complex and uncertain nature of the scientific record and its wish to have the benefit of further research -- for its conclusion that even if it had authority to regulate greenhouse gas emissions from motor vehicles, an endangerment finding would be inappropriate at this time.[32] As the D.C. Circuit stated in *Ethyl Corp. v. EPA*, 541 F.2d 1, 20 n.37 (en banc), *cert. denied*, 426 U.S. 941 (1976), the "express provision for administrative discretion via the 'judgment' phrase [in section 202(a)(1)of the Act] is necessary" precisely because that section requires EPA to initiate regulation once it makes a determination of "endangerment" to health or welfare. 541 F.2d at 20 n.37.

EPA's decision also took into account other legal and policy implications of any decision to initiate regulatory action at this time. Petitioners argue that "The existence of uncertainty is not a bar to regulation or an excuse for inaction and that an agency cannot defer action while it waits for scientific certainty." Petitioners' Brief at 41.

Nevertheless, the circuit court properly found no basis to disturb EPA's denial of the petition because an endangerment

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[32] *Amici* do not concur in EPA's reliance on the alleged uncertainty about global warming and its possible impact on society. There is no doubt that CO_2 levels in the atmosphere have risen faster than at any time in history and there is little doubt that the average world temperature has been increasing, probably as a consequence. There is a dispute about the exact amount of the increase and whether that increase will go on for 1,000 years or level off before then. However, there is much more doubt on the effect of such a temperature rise on the world's ecosystem. These doubts should not inhibit the adoption of a comprehensive system for understanding and cautiously regulating the overall problem of combustion of carbon-based fuels. But we believe that the Agency's ultimate decision not to regulate at this time, and the circuit court's sustaining of that determination, were correct because regulation of motor vehicle tailpipe emissions only in the United States would be ineffective and inefficient, and because an "endangerment" finding would mandate such regulation.

determination under the Act "'is necessarily a question of policy....'" 415 F.3d at 58, A-15 (quoting *Ethyl*, 541 F.2d at 24).

The Agency's conclusion that an endangerment determination is not appropriate at this time was properly upheld by the court of appeals because such a finding would mandate regulation, even though regulation might be ineffective or even counterproductive.[33]

Effectively increasing fuel economy standards would be the only way EPA could attempt to limit vehicle emissions of carbon dioxide, but such EPA regulation would conflict with the separate statutory scheme that Congress carefully developed and expressly crafted to address fuel economy standards, under which a division of the Department of Transportation is responsible for such standards. *See id.* 68 Fed. Reg. 52929-33. As the Agency noted, the rulemaking petition made "no suggestion" as to how emissions of the three greenhouse gases other than carbon dioxide that were the subject of the rulemaking petition might be reduced from motor vehicles." 68 Fed.Reg. at 52,931, Pet. App. A14. Petitioners do not explain in their brief to this Court how this might be achieved.

EPA cited other policy reasons that provide support for its decision to deny the rulemaking petition. 68 Fed. Reg. 52929-33, A-82 to A-92. Petitioners assert that EPA may not consider policy reasons under section 202 of the Act at all and that EPA's consideration of these reasons in this case impermissibly tainted the Agency's decision. Pet. Br. at 35-38. The circuit court properly rejected petitioners' argument, holding that "Congress does not require the Administrator to exercise his discretion solely on the basis of his assessment of scientific evidence." 415 F.3d at 58, A-13 (citing *Ethyl*, 541 F.2d at 20); *see id.*, A-15 ("as we have held, a reviewing court 'will uphold agency conclusions based on

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[33] Petitioners incorrectly assert that "A judgment in favor of petitioners will not mandate regulation of air pollutants associated with climate change, nor will it dictate a particular answer to the question whether such pollutants are endangering public health or welfare." Pet. Br. at 3. If that assertion is correct, then this case would seem to be pointless.

policy judgments' 'when an agency must resolve issues "on the frontiers of scientific knowledge"'") (quoting *Environmental Defense Fund v. EPA*, 598 F.2d 62, 82 (D.C. Cir. 1978)); *Ethyl*, 541 F.2d at 26 ("the statute accords the regulator flexibility to assess risks and make essentially legislative policy judgments"); *WWHT*, 656 F.2d at 818 ("The agency's determination is essentially a legislative one, and the reviewing court should do no more than assure itself that the agency acted 'in a manner calculated to negate the dangers of arbitrariness and irrationality.'") (quoting *Action for Children 's Television*, 564 F.2d at 472 n.24); *NRDC v. SEC*, 606 F.2d 1031, 1046 (D.C. Cir. 1979)("An agency's discretionary decision *not* to regulate a given activity is inevitably based, in large measure, on factors not inherently susceptible to judicial resolution. . . .") (emphasis in original).

Petitioners err in contending (Pet. 22-26) that further review is warranted because of the asserted urgency of the environmental issues involved. EPA, and *amici*, have never suggested that global climate change is not an important issue worthy of focused attention in the United States and in the world community. The EPA described in its decision in this case a variety of efforts that the federal government is currently undertaking to "effectively and efficiently address the climate change issue over the long term." Pet. App. at A82-A93. Those efforts, and others that could follow, are better tailored to address this worldwide issue than is the ill-suited regulatory machinery of the Clean Air Act, which could deal with only a small and isolated part of the problem, and ineffectually at that.

CONCLUSION

The decision of the Court of Appeals should be affirmed.

Respectfully submitted,

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APPENDIX A

AMICUS BIOGRAPHICAL INFORMATION

ERNEST L. DAMAN is Chairman *Emeritus* of Foster Wheeler Development Corporation where he previously served as Director of Research and Chairman of the Board. He also held the position of Senior Vice President at the parent company, FWC. He is a Past President of American Society of Mechanical Engineers and was elected to the National Academy of Engineering. Ernest Daman is a Fellow of the Institute of Energy (England) and the American Association for the Advancement of Science, and Past Chairman of the American Association of Engineering Societies. He served on several American Society of Mechanical Engineers committees as member or chairman. Ernest Daman is the author of numerous papers and holds 18 patents. He was responsible for the design and development of a combined steam gas turbine plant, fluidized bed combustion, fast breeder reactor components, supercritical steam generators, environmental control processes, and advanced high-efficiency power generation systems. Ernest Daman received his B.M.E. degree from the Polytechnic Institute of Brooklyn.

TOM A. HENDRICKSON is an independent consultant in the fields of energy, engineering, and technology. His career encompassed service to both government and industry. He was a Senior Executive of Raytheon Federal Engineers & Constructors, developing high technology projects. He was Principal Deputy Assistant Secretary of the Office of Nuclear Energy at the U.S. Department of Energy, where he oversaw programs including: Civilian Reactor Development; the Naval Nuclear Propulsion Program; Uranium Enrichment; Space and Defense Power Systems; Isotope Production; and Nuclear Safety Policy. He later became the Director of the New Production Reactors for the U.S. Department of Energy, responsible for designing and building new tritium production capacity for nuclear weapons; research and development; safety and environmental compliance; and construction. Concurrently, he served as Acting Under Secretary of Energy responsible for all defense and nuclear energy activities

of the department. Early in his career, he served on the staff of the Atomic Energy Commission in Washington, DC. He directed the headquarters staff and contractors involved in submarine nuclear propulsion engineering, including research, development, design, and construction of all new design nuclear powered submarines and land-based prototypes. During this period, he also served as Project Officer for all new submarine developments including the NR-1; the USS Los Angeles SSN-688 class of 62 attack submarines, and the electric drive submarine. He helped with the development of port-entry safety procedures and sea trials of the United States' first nuclear-powered surface ships, the USS Long Beach and the USS Enterprise; as well as the first refueling of the Shippingport Atomic Power Station. He is a member of the American Nuclear Society, the American Society of Mechanical Engineers, and the American Physical Society. Mr. Hendrickson received a B.A. degree in Physics from Harvard College and an M.S. degree in Physics from Georgetown University. He is a licensed Professional Engineer.

NATHAN H. HURT is a consultant in management and engineering with Technical and Management Consulting. He provides services to industrial firms and government agencies involved in environmental clean-up and waste management—both chemical and radioactive. He has extensive experience in the areas of executive management; plant management; engineering management; project management; marketing; and sales. He specializes in the areas of uranium enrichment/production; engineering; development and marketing; plant management of rubber chemicals; petrochemicals; and thermoplastics. He also specializes in the engineering management of synthetic rubber and lattices; vinyl monomers and copolymers; polyesters; U.S. Department of Energy (DOE) weapons plants; quality assurance management; and operational readiness review. Mr. Hurt has been involved with the decommissioning of nuclear facilities. He was the Corporate Sponsor or Program Manager for seven decommissioning contracts at the DOE Complexes in Oak Ridge, TN; and Pinellas, FL. Previously, Mr. Hurt was Director and Project Manager at the Oak Ridge Office of Sharp and Associates, Inc. He was Vice President and Director of Oak Ridge Operations

for IDM Environmental Corp., where he was responsible for the marketing and sales of decontamination, decommissioning, and waste management services. He served as Project Manager for the laboratory quality assurance program at Westinghouse Hanford and at DOE's Rocky Flats Plant. He managed a study for a waste treatment and storage facility at the Portsmouth Area Uranium Enrichment Facility which included incineration and compaction of low-level radioactive wastes. He also worked for Goodyear Tire and Rubber Company, including Goodyear Atomic, as Director of Research and Development, and President, where he was responsible for the operation of the Portsmouth Area Uranium Enrichment Facility. Nathan Hurt is a Past President of the American Society of Mechanical Engineers. He has been a member of: the American Association of Engineering Societies' Board of Governors; the American Institute of Chemical Engineers; and the Institute of Nuclear Materials Management. He is also a member of Tau Beta Pi Honorary Engineering Society; Pi Tau Sigma Honorary Mechanical Engineering Society; he was a member of The Nuclear Engineering Advisory Board of Worcester Polytechnic Institute. Mr. Hurt received a B.S. degree in Mechanical Engineering from the University of Colorado and has done graduate, technical, and management course work at Pennsylvania State University.

KLAUS S. LACKNER joined the faculty of Columbia University in 2001, where he is now the Ewing-Worzel Professor of Geophysics in the Department of Earth and Environmental Engineering. He has been a scientist in the Theoretical Division of Los Alamos National Laboratory since 1983, and also has been part of the Laboratory's senior management. He held several positions, among them Acting Associate Laboratory Director for Strategic and Supporting Research, which represents roughly a third of Los Alamos National Laboratory. Professor Lackner's scientific career started in the phenomenology of weakly interacting particles. He and George Zweig developed the chemistry of atoms with fractional nuclear charge while searching for quarks. He is still participating in matter searches for particles with a non-integer charge in an experiment conducted at Stanford by Martin Perl and his group. After joining Los Alamos National

Laboratory, Professor Lackner became involved in hydrodynamic work and fusion related research. In recent years, he has published on the behavior of high explosives, novel approaches to inertial confinement fusion, and numerical algorithms. His interest in self-replicating machine systems has been recognized by *Discover Magazine* as one of seven ideas that could change the world. Professor Lackner is currently developing innovative approaches to energy issues of the future. He has been instrumental in forming ZECA, the Zero Emission Coal Alliance, which is an industry-led effort to develop coal power with zero emissions to the atmosphere. Professor Lackner's recent work is on environmentally acceptable technologies for the use of fossil fuels. He holds degrees from Heidelberg University, Germany; Vordiplom, (B.S.) in 1975, Diplom (M.S.) in 1976, and Ph.D. in theoretical particle physics, *summa cum laude*, in 1978, and he won the Clemm-Haas Price for outstanding Ph. D. thesis at Heidelberg University. Professor Lackner attended the Cold Spring Harbor Summer School on Computational Neuroscience, 1985. He held postdoctoral positions at the California Institute of Technology and the Stanford Linear Accelerator Center before joining Los Alamos National Laboratory in 1983.

DENNIS K. McBRIDE is President of the Potomac Institute for Policy Studies, , a non-partisan, academic think tank providing science and technology policy expertise to the administration and the Congress. He is also a Research Professor at the Krasnow Institute for Advanced Study at George Mason University, an affiliated professor at the Georgetown University Public Policy Institute and at the Georgetown University Medical Center. Dr. McBride was previously the Executive Director, Institute for Simulation and Training at the University of Central Florida and professor of in the College of Engineering and Computer Science and in the College of Arts and Sciences. Dr. McBride completed a 20-year Naval career as a Naval officer/scientist with the grade of Captain, Medical Service Corps and flight test engineer. He earned gold wings in 1980, and his tours included bench-to-management science and technology at five Naval laboratories, three major headquarters organizations (including the Office of Naval Research (ONR) and the Defense Advanced Research

Projects. Trained as a flight test engineer at the University of Tennessee Space Institute, Dr. McBride was selected by the Navy as a mission specialist astronaut. Dr. McBride has led or participated in numerous National Research Council, National Academies studies, and he has published and/or presented more than 120 papers, including his most recent book, in several fields of science, engineering, and medicine. He served as Editor-in-Chief for *Review of Policy Research*, and he currently is Co-Editor-in-Chief for *Technology* in addition to serving on several editorial boards for academic journals. Dr. McBride earned a B.S. in Psychology (concentration in biological psychology) from the University of Georgia, an M.S. in Experimental and Differential Psychology (concentration in statistical methodology) from the University of Georgia, a Ph.D. in Experimental Psychology (concentration in mathematical learning theory) from the University of Georgia, an M.S./M.P.A. in Public Policy from Troy State University (concentrating on government sponsorship of R&D), an M.S. in Systems from the University of Southern California (focusing on probabilistic and deterministic modeling).

A. ALAN MOGHISSI is President of the Institute for Regulatory Science (RSI), a non-profit organization dedicated to the idea that societal decisions must be based on the best available scientific information. The activities of the Institute include research, scientific assessment, and science education at all levels-particularly the education of minorities. Dr. Moghissi held positions at the U.S. Public Health Service and, upon its formation, the U.S. Environmental Protection Agency (EPA). He served in a number of capacities at EPA, including Director of the Bioenvironmental/Radiological Research Division; Principal Science Advisor for Radiation and Hazardous Materials; and Manager of the Health and Environmental Risk Analysis Program. After his retirement from the EPA, Dr. Moghissi joined the University of Maryland at Baltimore as Assistant Vice President for Environmental Health and Safety; subsequently he was Associate Vice President for Environmental Health and Safety at Temple University in Philadelphia, Pennsylvania. He has been a visiting professor at Georgia Tech and at the University of Virginia. Dr. Moghissi's research has dealt with diverse subjects,

ranging from measurement of pollutants to the biological effects of environmental agents. A major segment of his research has been on scientific information upon which laws, regulations, and judicial decisions are based -- notably risk assessment. Dr. Moghissi's research has included biological and environmental kinetics, but increasingly with the development and implementation of the concept of Best Available Science (BAS) in societal – including regulatory – decisions. He has published over 300 papers and several books. He was the editor-in-chief of *Environment International* and *Waste Management* and editor-in-chief of *Technology* traces its roots to the *Journal of The Franklin Institute*, one of America's oldest continuously published journals of science and technology. Dr. Moghissi is a member of the editorial board of several other scientific journals. He is a member of the Advisory Committee of the Environmental Engineering Division of the American Society of Mechanical Engineers. Dr. Moghissi also serves on the U.S. National Commission for UNESCO, a Federal Advisory Committee to the Department of State that provides expert advice to the State Department on issues of Education, Science, Communications and Culture. Dr. Moghissi received his education at the University of Zurich, Switzerland, and Technical University of Karlsruhe, Germany, from which he received a doctorate in physical chemistry.

HAROLD W. OLSEN is a Research Professor in the Division of Engineering and the Department of Geology and Geological Engineering at the Colorado School of Mines. His research includes the development and application of new experimental capabilities for geotechnical measurements. These measurements are on undisturbed core samples that provide experimental control on the chemistry and degree of saturation of soil pore fluids and on arbitrary stress and strain paths. The measurements minimize the need for replicate specimens. The hazards of interest include: landslides; subsidence; expansive soils; and subsurface contamination. He is also a Scientist *Emeritus* of the U.S. Geological Survey, where he supports geologic and environmental hazard investigations, and his research involves interrelationships among the geologic characteristics of unconsolidated earth

materials and their geomechanical and hydrologic properties. Additionally, he is currently working on a National Aeronautics and Space Administration contract through the University of Colorado entitled *Identification and Mapping of Expansive Clay Soils in the Western U.S. Using Field Spectrometry and AVIRIS Data*; and a National Science Foundation grant entitled *The Importance of Osmosis in the Volumetric Behavior of Earth Materials.* Professor Olsen has worked as a Research Civil Engineer at the U.S. Geological Survey Engineering Geology Branch and Earthquake and Landslide Hazards Branch, where he conducted reviews of geotechnical aspects of Preliminary Safety Analysis Reports concerning proposed nuclear reactor sites for the Atomic Energy Commission, and contributed to the development of geotechnical capabilities for the Branch Energy Lands Program. Additional projects included both physicochemical and physical phenomena that can increase the vulnerability of ground to failure with time, and that can be used to strengthen and stabilize weak or failed ground; these phenomena include chemical causes of groundwater movement, and chemical and saturation effects on the permeability, compressibility, and strength of argillaceous materials. Professor Olsen has worked as a Geotechnical Consultant in the U.S. Geological Survey Technical Assistance Programs in Peru, Indonesia, and Bangladesh. He is an expert on soil properties and behavior, and the application of geotechnical data to studies of terrestrial and marine environments. Professor Olsen is a member of the American Society of Civil Engineers (ASCE) Geo-Institute Committee on Technical Publications, and Editor-In-Chief of the ASCE Journal *Geotechnical and Geoenvironmental Engineering.* His current professional society activities include membership in the Organizing Committee for the ASCE Geo-Institute Conference; Organizing Committee for an Expansive Soil Research Center at the University of Colorado, Denver; Awards Committee, Geotechnical Engineering Division, ASCE; ASCE Committee on Engineering Geology; American Society for Testing and Materials Committee D-18 on Soil and Rock for Engineering Purposes; and Highway Research Board Committee A2L03 on the Physicochemical Properties of Soils. He has

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PAOLO F. RICCI is currently both Research Professor Environmental Science at the University of San Francisco, CA and Honorary Professor at the University of Queensland, NRCET, Brisbane, Australia. Over the last 20 years, he has taught graduate courses in epidemiology, risk assessment and management, and applied economics in Thailand, Italy, Philippines, China, Hungary and several other countries as well as the United States. Professor Ricci has been Associate Professor at Stanford University and at U.C.L.A. (School of Public Health) and an Adjunct Full Professor of Law at the University of California at Berkeley. From 1994 to 2000, he was Associate Professor (equivalent to U.S. Professor) of Public Health and Head of the Risk Analysis Unit (New South Wales Department of Health, Sydney), as well as Professor (equivalent to US Professor with Chair) at the University of Wollongong (Faculty of Law), Australia; he has also been Faculty Scholar at Lawrence Livermore National Laboratory. Professor Ricci has been the Head of the Technology Clearinghouse of the IEA/OECD). In the last four years, he has served as a peer reviewer of the United States Department of Energy (DOE) activities regarding the human health risks from past nuclear and thermonuclear tests at the Nevada Test Site, and in the reviews of other DOE activities at their facilities, including Hanford nuclear reactor sites. Professor Ricci has led and conducted qualitative and quantitative analyses and experimental work, for approximately 30 years, in the United States, Canada, Italy, Australia, France, Vietnam, China, and the European Union. He has reviewed national water guidelines, in the context of the Federal Drinking Water Guidelines for 1995, for the Australian Federal Government. Professor Ricci is a member of the American Association for the Advancement of Science. He served on the Australian National Medical Research Council – the key federal Australian committee that governs medical and health scientific research for Australia – and chaired sections and

presented papers at national and international conferences dealing with air and water pollution. He was Guest Editor of the American Society of Civil Engineers' *Journal of Energy Engineering, Environment International,* and the *Journal of Hazardous Waste Management.* Professor Ricci has written and edited five books. He has authored more than 100 scientific publications in journals such as *Science; Environmental Science and Technology; Environment International; Environmental Research; the Journal of the Air and Waste Management Association; the Medical Journal of Australia*; and several other international peer-reviewed journals. He has also published several law review articles. Professor Ricci holds an M.A. degree in Economics from Temple University, an LL.M degree from Leicester University, U.K., an M.P.A. degree from the Kennedy School of Government at Harvard University, and Ph.D. and M.Sc. degrees in Engineering and Sciences from Drexel University.

PETER P. ROGERS is Gordon McKay Professor of Environmental Engineering and Professor of City and Regional Planning in the Division of Engineering and Applied Sciences at Harvard University. He is a member of the Technical Advisory Committee of the Global Water Partnership and a recipient of Guggenheim and Twentieth Century Fellowships. Professor Rogers has carried out extensive field and model studies on population, water and energy resources, and environmental problems in Costa Rica, Pakistan, India, China, the Philippines, Bangladesh and, to a lesser extent, in 25 other countries. His most recent work has focused on the relationship between Chinese electric power developments and their impact on global warming. Recent books include: AMERICA'S WATER: FEDERAL ROLES AND RESPONSIBILITIES, A Twentieth Century Fund Book (1993); WATER IN THE ARAB WORLD: PERSPECTIVES AND PROGNOSES (1994); MEASURING ENVIRONMENTAL QUALITY IN ASIA (1997), SUSTAINABILITY (2005). Professor Rogers received his B. Engineering (1958) from the University of Liverpool, his M.S. in Engineering (1961) from Northwestern University and his Ph.D. in Engineering (1966) from Harvard University.

CHARLES O. VELZY is a consultant in the field of waste treatment and disposal. Previously, he held increasingly responsible positions with the environmental consulting engineering firm, Charles R. Velzy Associates, Inc., becoming President in 1976. In 1987, when Velzy Associates merged with Roy F. Weston, Inc., Charles Velzy became Vice President of Weston, a position which he held until retiring in 1992. He has over 35 years of experience as an environmental engineering consultant specializing in: the analysis of waste management problems; design of wastewater treatment and waste disposal systems; and design of new, retrofit of existing, testing, and permitting of waste combustion facilities. He has authored or co-authored over 80 publications – primarily in the field of solid waste management. He has served on the Science Advisory Board of the U.S. Environmental Protection Agency; as President of the American Society of Mechanical Engineers (ASME); Chair of the ASME Peer Review Committee; and as Treasurer of the American Academy of Environmental Engineers (AAEE). He has served on numerous committees of the ASME, the AAEE, the American National Standards Institute, and the American Society for Testing and Materials. He is a registered professional engineer in New York and eleven other states. Charles Velzy received B.S. degrees in Mechanical and Civil Engineering, and an M.S. in Sanitary Engineering from the University of Illinois at Urbana-Champaign.

RICHARD WILSON is Mallinckrodt Research Professor of Physics at Harvard University and immediate past Director of the Regional Center for Global Environmental Change at Harvard University. He is an Affiliate of the Center for Science and International Affairs and the Center for Middle Eastern Studies at Harvard University. Professor Wilson is a past Chairman of the Department of Physics at Harvard University, a past chairman and currently a member of the Cyclotron Operating Committee. He is a founder of the Society for Risk Analysis. He is and has been a consultant to the United States government and the governments of numerous foreign countries on matters of nuclear safety, toxicology, epidemiology, public health and safety and risk assessment. Professor Wilson's areas of expertise include

elementary particle physics, radiation physics, chemical carcinogens, air pollution, ground water pollution by arsenic, and human rights. He is the author of many articles on high energy physics, environmental pollution and risk analysis, including PARTICLES IN OUR AIR, EXPOSURES AND HEALTH EFFECTS (with Editor John Daniel Spengler) (Harvard University Center for Risk Analysis, 1986) and RISK-BENEFIT ANALYSIS (with Edmund A. C. Crouch) (Harvard University Center for Risk Analysis, 2nd ed. 2001). Professor Wilson is the author or co-author of more than 880 published papers on subjects including atomic particles, radioactive particle decay, shielding of particle accelerators and nuclear reactors, nuclear energy production, health risks of nuclear power plant accidents, risk benefit analysis, public health, acute toxicity and carcinogenic risk, carcinogenicity bioassays, statistical distributions of health risks, cancer risk management, health effects of electromagnetic fields, risks and health impacts of radiation, risks of nuclear proliferation and global energy use and global warming.